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RESULTS OF AN EXPERIMENT ON THE IMPROVEMENT OF SANDY SOIL WITH RIVER SILT

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INTRODUCTION

The use of river-borne silt to maintain soil fertility is one of the most ancient agricultural practices of man. The Egyptians, for more than 4,000 years, have depended upon the annual inundations of the Nile to supply fertilizing mud to their soil. Their basin irrigation works from the time of the Pharoahs have been designed to catch and hold the finely divided red sediment which is brought down each year by the Nile from the Abyssinian Plateaus. The Biblical saying, "Cast thy bread upon the waters ...." (Eccl. 11:1), alludes to the ancient method of throwing seed upon the receding flood waters of the Nile so that the seed would be carried down with and germinate in the fertile sediment.

History records that George Washington, in 1785, attempted to obtain a dredge to recover Potomac River mud for application to the soil on his Mount Vernon estate, and the standing toast there, according to Noah Webster, was "Success to the mud." Throughout many centuries and in many countries, including England, France, Switzerland, Italy, Turkestan, India, and China, river sediments have been utilized for improving and reclaiming land. Although the methods of application of sediment have varied in different areas, the objectives have always been the same--to build, improve, and enrich land by the application of water-borne sediment.

The following resolution was passed by an Agricultural Conference held at Ravenna, Italy, June 7, 1904: "That wherever fertilizing silt is available, it is a grave economical error not to profit by it."

Because increased food production is required to meet military, Lend-Lease, and domestic needs during the war, it is highly important at this time that we maintain the fertility of our soil and keep up food production by all possible means. Since certain commercial fertilizers, especially those containing high nitrogen content, may not be available in as large quantities as formerly, the farmer should be on the alert for other possible means of fertilizing his land. Farmers will find it generally advisable or necessary to depend more heavily on legumes, farm manure, soybean meal, and cottonseed meal, to supplement nitrogen fertilizers.

Where farms are adjacent to streams that carry and deposit silt, it may be possible to use this material as an aid toward maintaining the productivity of certain types of soils. Many farms in the United States are relatively close to sources of silt, including some farms that are submarginal and are not now producing their share of the Nation's food crops. Conditions that appear to be favorable to the beneficial use of silt on farm land are: (1) that the original soils are relatively sandy or open-textured, (2) that the silt contains essential plant nutrients which become available in a relatively short time, and (3) that the silt can be obtained and spread over the land at a reasonable cost.

This paper is a description of a preliminary experiment conducted during the spring of 1937 to determine the yield of millet on Sassafras loamy sand from a submarginal farm near Upper Marlboro, Md., when this soil is treated under greenhouse conditions with an admixture of various quantities of silt obtained from the adjacent Patuxent River. Although the lack of sufficient replication of pots, and the absence of adequate experimental control, prevent the results from being fully acceptable statistically, the data do suggest that this soil could be materially improved under field conditions by silt admixture if facilities were available for placing silt on the land.

In general, the experiment consisted of setting up a number of pots containing Sassafras loamy sand obtained directly from a cultivated field in Maryland. To the soil in each of these pots was mixed a measured quantity of silt obtained from the Patuxent River. Millet was used as a test crop, and the growth rate and dry weight of the straw and grain were used as a basis of comparison of productivity of individual pots.

Source of Samples

The Patuxent River has a drainage area of 963 square miles, lying entirely within the State of Maryland. The upper part of the watershed lies on the Piedmont Plateau and the lower part on the Coastal Plain, these regions being the main physiographic subdivisions of the Atlantic Slope. The Piedmont Plateau is underlain largely by crystalline rocks, principally granites, gneisses, and schists, which give rise to residual Chester and related soils; and the Coastal Plain is underlain by unconsolidated clays, sands, and gravels, which give rise to Sassafras and Collington soils. The drainage area is to a large extent rural and agricultural.

There are approximately 20,000 acres of Sassafras loamy sand adjacent to the Patuxent River and its tributaries. It is estimated that about 50 percent of this area is not in cultivation at present, although most of it has been cleared and cultivated at one time or another. The soil, because of its porous nature, warms up readily in the spring and for this reason is used principally by truck growers. It requires, however, a heavy annual application of fertilizer and manure.

The Sassafras loamy sand used in this experiment was obtained from the upper 6 inches of a field, last cultivated in 1934, on the Sutherland farm, located on the left bank of the Patuxent River in the southern part of Anne Arundel County. The land on this farm has been in cultivation for many years, and has deteriorated to such a degree that after a field is cropped for 1 year it is taken out of cultivation for at least 3 years in order to produce another satisfactory crop. The principal crops are corn and tobacco.

The silt used for the treatment of the Sassafras loamy sand in the pot cultures was obtained from various sections of the Patuxent River adjacent to the Sutherland property. In this vicinity the river, with a tidal range of 2.5 feet, flows in a submerged valley which contains numerous mud flats. The valley opposite the Sutherland farm is considerably wider than that part of it immediately upstream and, as a result, there is a reduction of velocity, with a corresponding decrease in silt-carrying capacity, of the waters entering this section of the river. Consequently, sedimentation in this section is very rapid. A 9-foot channel, dredged in 1891 to a point approximately 4 miles above the Sutherland property, has since filled up with sediment derived, for the most part, from the upland soils of the watershed.

The silt was taken from the river with a post-hole digger and removed to the University of Maryland greenhouse, where it was allowed to dry preparatory to mixing with the Sassafras loamy sand. The silt dried rapidly and formed very hard lumps, making it necessary to use a hammer to pulverize them. A lump placed outside the greenhouse, where it was acted upon by natural weathering conditions, including temperature changes and alternate wetting and drying, crumbled to a loose soil after several months of exposure. Each rain had a noticeable effect upon the disintegration of this lump. Samples of wet and dry silt, together with samples of soil, were chemically analyzed by Dr. R. P. Thomas, Professor of Soils at the University of Maryland. The results of this analysis, obtained by rapid soil-testing methods, are given in table 1.

Table 1.--Approximate available elements in pounds per acre of 7 inches calculated from rapid soil-test analyses of silt from Patuxent River and Sassafras loamy sand from adjoining land

Available elements	Silt										Soil	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Calcium	150	1500	2500	2500	2500	3500	3500	3500	3500	2500	150	0
Magnesium	60	175	175	175	175	120	175	175	175	120	20	5
Aluminum	400	400	400	200	400	400	400	400	600	600	200	200
Iron, ferric	200	200	200	75	200	200	200	200	700	700	0	0
Nitrogen, nitrate.	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Nitrogen, ammonia.	2.5	2.5	2.5	10	10	2.5	10	10	38	38	2.5	0
Phosphorus	5	0	5	0	0	0	5	5	5	5	0	30
Potassium	250	400	400	600	600	600	600	600	150	50	250	150
Manganese	15	15	15	150	150	15	75	15	75	75	0	0
Chlorine	0	0	0	0	0	0	0	0	0	0	0	0
Sulfates	0	0	0	0	0	0	0	0	+	+	0	0
pH value	3.4	4.6	6.7	5.8	5.0	4.2	5.0	5.5	5.6	4.3	5.1	4.9

(1) to (8) -- Silt from different parts of the river.
(9) --------- Silt used in pot cultures, several days aeration.
(10) -------- Composite of (1) to (8), after 2 months weathering.
(11) -------- Soil from field cultivated in 1936.
(12) -------- Soil used in pot cultures, cultivated in 1934.

After several weeks' aeration the silt was thoroughly mixed with the Sassafras loamy sand in various proportions by volume. It was considered that a pot containing 5 parts of soil to 1 part of silt was equivalent to a field plowed to a depth of 6 inches, upon which 1 inch of silt had been added. All pots were set up in duplicate, each containing approximately 11 kilograms of soil. Fertilizer was added at the rate of 0.25 gram per kilogram, which was taken to be equivalent to 500 pounds per acre. The fertilizer, like the silt, was thoroughly mixed with the soil.

The following pots were established in duplicate:

Pot A - original soil with no treatment. Field cropped in 1934.

Pot B - 1 part of silt to 5 parts of original soil by volume, equivalent to 1 inch of silt on field.

Pot C - 2 parts of silt to 4 parts of original soil by volume, equivalent to 2 inches of silt on field.

Pot D - 3 parts of silt to 3 parts of original soil by volume, equivalent to 3 inches of silt on field.

Pot E - 4 parts of silt to 2 parts of original soil by volume, equivalent to 4 inches of silt on field.

Pot F - all silt as taken from the river, not as thoroughly aerated as silt used in other pots. Equivalent to plow-slice depth.

Pot G - original soil with no silt but with 4-8-5 fertilizer added at the rate of 500 pounds per acre.

Pot H - 1 part of silt to 5 parts original soil by volume with superphosphate added at the rate of 500 pounds per acre.

Pot I - 1 part of silt to 5 parts of original soil by volume with ammonium sulfate added at the rate of 250 pounds per acre.

Approximately 30 seeds of German millet, a variety of Foxtail millet (Setaria italica), were planted in each pot. Water was added to each pot in equal quantities at regular intervals. When the plants reached several inches in height, all but the ten most hardy plants were removed from each pot. Tabulation of the average height of plants began the fourth week after planting, and was continued each week thereafter through the twelfth.

Tables 2 and 3 give the average height, the average dry weight of grain and straw, and the percentage increase over the original soil based on 20 plants for each set of pots.

Table 2.--Average height of plants for various soil treatments

Pot	Treatment	Weeks after planting								
		4	5	6	7	8	9	10	11	12
		Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.
A	No treatment	2.9	4.8	8.6	15.6	27.5	47.4	53.5	70.2	85.7
B	1" silt	4.8	10.9	23.1	39.5	64.8	80.9	97.3	115.6	126.1
C	2" silt	7.2	15.5	26.0	43.8	69.7	86.9	105.6	125.0	134.3
D	3" silt	4.3	10.5	21.7	40.2	62.2	88.1	105.7	124.5	135.5
E	4" silt	5.8	13.4	25.3	41.1	63.8	86.5	102.7	128.7	134.3
F	All silt	7.0	14.1	25.5	45.0	65.2	88.7	101.3	126.1	140.1
G	4-8-5 fertilizer	3.9	6.9	12.6	23.2	40.3	65.4	86.0	109.0	121.5
H	1" silt and superphosphate ...	4.6	12.0	23.0	42.5	59.0	79.5	94.3	120.9	126.6
I	1" silt and ammonium sulfate .	4.2	8.4	16.8	32.3	51.4	70.9	85.9	106.5	119.6

Table 3.--Weight of grain and straw for various soil treatments, in grams and in percent of increase over original soil

Pot	Treatment	Straw		Grain	
		Weight	Increase	Weight	Increase
		Grams	Percent	Grams	Percent
A	No treatment	107	---	22.02	---
B	1" silt	307	187	74.68	239
C	2" silt	328	207	75.60	243
D	3" silt	321	200	65.45	197
E	4" silt	334	212	83.24	278
F	All silt	335	213	83.82	281
G	4-8-5 fertilizer	210	96	40.87	86
H	1" silt and superphosphate	326	205	72.05	227
I	1" silt and ammonium sulfate	241	125	55.50	152

Discussion of Results

Tables 2 and 3 show that the mixing of Patuxent River silt with Sassafras loamy sand results in an enormous increase in the yield of millet under greenhouse conditions. The application of a 4-8-5 fertilizer at the rate of 500 pounds per acre gave an increase in yield of only 86 percent over that of the original soil, while the application of 1 inch of silt gave an increase of 239 percent.

The effect of mixing silt in various proportions to the original soil is illustrated in Figures 1 and 2. These curves show a great increase with the addition of the first inch of silt to the original soil, but only a relatively small, though gradual, increase for each additional inch after the first. The yield measurements of the pot containing 3 inches of silt showed a deviation from this trend; and, although it is still within the limits of error, it is thought that part of the grain and straw from this pot was lost in the process of developing a satisfactory method of separating the grain from the chaff. In all other pots the average height of the plants and the yield of grain showed a definite relationship to the amount of silt mixed with the original soil.

In order to determine whether there was a deficiency of available phosphorus in the silt, Pot H, containing a soil-silt mixture of 1 part of silt to 5 parts soil, was set up and superphosphate added at the rate of 500 pounds per acre. Since no increase in yield was obtained over the pot containing 1 inch of silt to 5 parts of original soil and with no fertilizer, it is believed a sufficient amount of available phosphorus was present in the silt at least to supply the needs of millet.

A similar test was made for available nitrogen by adding ammonium sulfate, at the rate of 250 pounds per acre, to a silt-soil mixture composed of 1 part of silt to 5 parts of soil. This pot showed a substantial decrease in yield as compared to that for the pot containing only 1 inch of silt to 5 parts of original soil and no fertilizer. It is thought that this fertilizer may have had an acidulating effect on the silt-soil mixture which caused a decrease in yield.

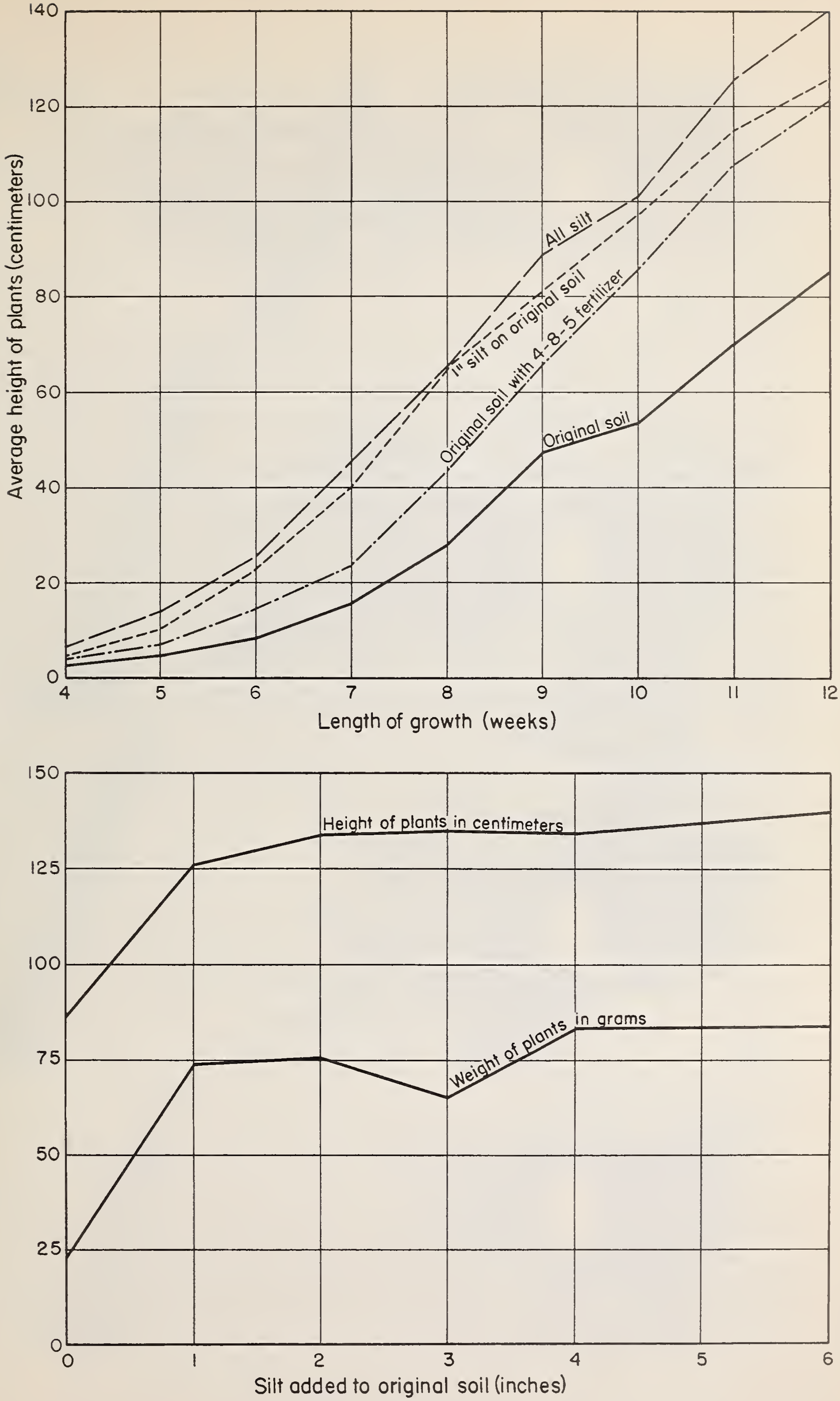

Figure I. - Curves showing the growth rate and production of millet on sassafras loamy sand for different soil treatments.

Figure 2.— Two-month growth of millet under different soil treatments. (1)Original sassafras loamy sand, (2) original soil with 4-8-5 fertilizer, (3) original soil with 1-inch Patuxent silt, (4) all silt.

CONCLUSIONS

It is believed that the increase in the yield of millet caused by mixing silt with the soil is due mainly to the fertilizing and soil-conditioning effect of the silt. An inspection of the watershed showed that the silt load of the Patuxent River is derived almost entirely from sheet erosion of the topsoil and that only a minor amount is derived from gullying of the subsoil. The most fertile part of all of the soils of the Patuxent River watershed, therefore, has contributed, year after year, to the silt deposits from which the samples for this experiment were obtained. It is apparent that the fertilizing effect of this silt must be great to an impoverished soil such as the Sassafras loamy sand.

The increase in yield of millet may have been due in part to the effect the silt may have had in decreasing the hydrogen-ion concentration of the original soil. This soil had a pH value of 4.9, whereas that of the silt was determined to be 5.6. Mixing the two probably resulted in a somewhat less acid soil condition than that of the original soil, and this, in turn, has had some effect in producing an increased yield of millet.

Inasmuch as the plants received sufficient water at all times in the greenhouse, any increase in yield due to improvement of the water-holding capacity of the silt-soil mixtures probably was small. The improvement of the water-holding capacity, however, would be of greater importance under actual field conditions than it would be under greenhouse conditions.

This experiment, conducted under greenhouse conditions, suggests that the admixture of a limited quantity of Patuxent River silt to Sassafras loamy sand adds considerably to the yield of millet on this soil. Before final conclusions can be drawn, however, the experiment would have to be repeated with other types of crops on a much larger scale, preferably under field conditions. This experiment serves primarily to emphasize the need for further studies along these lines to determine whether the yields of essential food and fiber crops could be increased in a similar manner under field conditions and at a reasonable cost.

Along the outer edge of the Coastal Plain region of the United States there are numerous estuaries which are similar in origin to that of the Patuxent River. These hold millions of cubic yards of sediment, while adjacent to them are large areas of sandy non-productive Sassafras and Norfolk soils which are generally quite similar to the soil used in this experiment. These soils, in many cases, probably could be improved if the sediment proved to increase the productivity of these

soils to the same degree as that indicated by the Patuxent River sediment in the experiment described. This practice warrants consideration inasmuch as the Coastal Plain area has today the greatest fertilizer consumption of any area of equal size in the United States. During 1938, 50 percent of all of the fertilizer sold in the United States was consumed in the South Atlantic region, nearly a third of this in North Carolina alone. A serious fertilizer shortage would have a pronounced effect in this section. As a wartime conservation measure, the use of silt might be considered, after adequate testings, as a possible supplement to commercial fertilizer in this region. Farmers might profitably set aside small areas of their fields where experiments similar to the one described above could be conveniently carried out under field conditions.